CONVEYOR OVEN

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Application Number 60/550,578, filed March 5, 2004, entitled "SPEED COOKING CONVEYOR OVEN"; the benefit of U.S. Provisional Application Number 60/551,268, filed March 8, 2004, entitled "ANTENNA COVER; and the benefit of U.S. Provisional Application Number 60/615,888, filed October 5, 2004, entitled "CATALYST FOR SPEED COOKING OVEN".

The present application is a continuation-in-part of U.S. Application Serial Number 10/614,479, filed July 7, 2003, entitled "SPEED COOKING OVEN", currently pending, which claims the benefit of U.S. Provisional Application Number 60/394,216, entitled "RAPID COOKING OVEN", filed July 5, 2002; a continuation-in-part of U.S. Application Serial Number 10/614,268, filed July 7, 2003, entitled "MULTI RACK SPEED COOKING OVEN", currently pending, which claims the benefit of U.S. Provisional Application Number 60/394,216, entitled "RAPID COOKING OVEN", filed July 5, 2002; a continuation-in-part of U.S. Application Serial Number 10/614,710, filed July 7, 2003, entitled "SPEED COOKING OVEN WITH GAS FLOW CONTROL", currently pending, which claims the benefit of U.S. Provisional Application Number 60/394,216, entitled "RAPID COOKING OVEN", filed July 5, 2002; a continuation-in-part of U.S. Application Serial Number 10/614,532, filed July 7, 2003, entitled "SPEED COOKING OVEN", currently pending, which claims the benefit of U.S. Provisional Application Number 60/394,216, entitled "RAPID COOKING OVEN", filed July 5, 2002.

The present application contains technical disclosure in common with PCT/US03/021225, entitled "SPEED COOKING OVEN" filed July 5, 2003, currently pending, which claims the benefit of U.S. Provisional Application Number 60/394,216, entitled "RAPID COOKING OVEN", filed July 5, 2002; and contains technical disclosure in common with PCT/US04/035252 entitled "SPEED COOKING OVEN WITH SLOTTED MICROWAVE ANTENNA", filed October 21, 2004, which claims the benefit of U.S. Provisional Application Number 60/513,110, filed October 21, 2003, entitled "SLOTTED ANTENNA", which also claims the benefit of U.S. Provisional Application Number 60/513,111, filed October 23, 2003, entitled "MICROWAVE ANTENNA COVER FOR RAPID COOKING OVEN", which also claims the benefit of U.S. Application Number 60/614,877, filed September 30, 2004, entitled "SLOT ANTENNA". Each of these applications are incorporated herein by reference as if fully set forth.

BACKGROUND

The typical cook time for a food product such as a fresh medium size pizza (12 to 14 inch) through a conventional conveyor oven is approximately 7 minutes, and 15 minutes through a deck style oven. The conveyor oven reduces cooking time as compared to the deck oven and also simplifies the cooking procedure because the food product is automatically loaded into and unloaded from the cooking tunnel.

Conveyor ovens typically utilize a continuous open link conveyor belt to transport food products through a heated cooking tunnel which has openings at each end of the oven through which the conveyor belt sufficiently extends in order for the operator to start incoming food product on one end, and retrieve the finished cook product from the other. These conveyor oven

tunnels are generally open at each end and in instances wherein microwave energy is used, long entrance and exit tunnels are required in order to reduce the amount of microwave energy exiting the tunnel ends. Pizza output capability for such a large conveyor oven is generally approximately 100 to 120 medium pizzas per hour.

Although cooking speed is important, food quality is also very important. Quality is generally highest when the food product is cooked and presented to the consumer as soon as possible (cooked to order). As such, food service operators must provide fast service in addition to a high quality food product and pre-cooking and holding food is therefore not desirable because the quality is substantially less than that of a cooked to order food product.

A conveyor oven virtually guarantees that a cooked food product will be removed from the oven at the proper time, but conveyor ovens have not generally been compatible with some type of food service operations such as: quick service restaurant (QSR); consumer operated ovens where the consumer is a retail customer at a retail location such as a convenience store; or retail foodservice locations with no room for a large conveyor oven, to name a few.

SUMMARY

It has now been found that the above objects are obtained in a conveyor oven with at least one cooking zone and employing gas flow to cook, or re-thermalize a food product. The gas flow to the food product is such that conflicting and colliding gas flows produce high heat transfer at the food product surface. Our conveyor oven may also utilize microwave energy, or other means such as radio frequency, induction and other thermal means, to further heat the food product. Microwave producing magnetrons are used with side wall mounted microwave waveguides employing the use of slotted antenna, although it is not necessary that the microwave system launches from the oven cavity side walls and indeed launching microwaves from other

oven cavity surfaces may be employed. Our conveyor oven may operate as a conventional speed, an accelerated speed or a speed cooking conveyor oven. the speed cooking conveyor oven is described herein as an exemplary embodiment or version. The speed cooking conveyor oven has a cooking tunnel with one or more discrete cooking zones and conveyor transport means that moves or indexes food product through the cooking tunnel with product loading and un-loading areas located prior to and after the cooking tunnel. The conveyor loading area for food product is sized such that the available area for food product is smaller than the area of each cook zone of the cooking tunnel. Gas flow and microwave energies (when microwaves are used) are distributed to the food product in a manner that produces uniform cooking and heating and a typical cook zone temperature range may be in the approximately 375°F (190 degrees Celsius "C") to approximately 500°F (260°C) range, although cook zone temperatures below 375°F (190°C) and above 500°F (260°C) may be utilized. Gas flow throughout the cooking tunnel is common to all cook zones and a common heating means provides hot gas for the cooking tunnel. Cooking controls permits a wide variety of food products to be run sequentially through the cooking tunnel with each food product having a unique cooking profile, or recipe, that will be executed in a sequential format as the food product moves, or indexes, through the cooking zones. The indexing conveyor of the exemplary embodiment operates at a fixed rate, that is, each cook zone holds food product for the same length of time, but the indexing time may vary or may be altered or otherwise set according to the needs of the operator.

An optimum speed cooking conveyor oven will maintain the convenience of a conventional conveyor oven but cook a fresh food product such as a medium pizza to a high quality level in less than 3 minutes, thereby representing an approximately fifty percent decrease in cooking time over the conventional conveyor oven. The more than double increase in

production rate of our invention over the conventional conveyor oven represents a significant decrease in cooking time and may allow a foodservice operation to increase the number of customer served by: adding a drive-through operation; increasing table service turn rates; implementing a consumer operated conveyor oven, or enabling a quick walk-in/take out function, to name a few. For operations that currently require multiple ovens to meet customer demand, the significantly reduced cook times of our speed cooking conveyor oven permits the same collective food throughput with fewer ovens.

In addition to such items as pizza, our invention is capable of warming and cooking a wide variety of foods such as seafood, Mexican food, hot dogs, sausage, sandwiches, casseroles, biscuits, muffins, french fries, fresh and frozen appetizers, fresh proteins, pies, bread products, and indeed, any food product that can be cooked in a conventional oven. Generally, conventional conveyor ovens do not have a tall cooking tunnel but because different food products are of varying volumes, heights and size profiles, a tall cooking tunnel is desirable for cooking various food products and the cooking tunnel of our invention allows for such cooking of various food products. It is also desirable to keep energy consumption as low as possible. In order to accomplish reduced energy costs, our invention utilizes recycling gas flow and reduces heat loss from the tunnel ends. Not only is energy savings a benefit, reduction of heat loss from the tunnel ends improves the effective energy transfer to the food product. Our speed cooking conveyor oven is also simple and safe to operate, easy to clean and maintain, easy to service and low cost to manufacture.

Accordingly, it is an object of the present invention to provide a conveyor oven capable of cooking and warming a broad variety of food products with varying size and volume profiles either at conventional or speed cooking times.

A further object is to provide such a conveyor oven that is energy efficient, simple and safe to operate, simple and easy to clean, easily serviceable and has a low manufacturing cost.

Still another object is to provide such a conveyor oven that is capable of cooking high quality food product within metal pans, pots, sheet pans and other metal cooking devices commonly found in residential, commercial and vending venues.

It is a further object to provide such an oven with a microwave distribution system which is more cost effective to manufacture and easy to clean and maintain.

Yet another object is to provide such a microwave distribution system that is reliable due to improvements and simplifications.

Still another object is to provide such an oven that can be easily and quickly programmed by an operator to cook various food products with the touch of a button or such an oven that automatically inputs cooking recipes into a controller without human intervention.

Additional objects, features and advantages of the present invention will become readily apparent from the following detailed description of the exemplary embodiment thereof, when taken in conjunction with the drawings wherein like reference numerals refer to corresponding parts in the several views.

DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a front view of the conveyor oven of the present invention illustrating gas flow supply;

FIG. 2 is a front view of the conveyor oven of the present invention illustrating gas flow return;

FIG. 3 is a top view of the conveyor oven of the present invention ;

FIG. 4 is top view of the conveyor oven of the present invention illustrating product location relative to cook zones;

FIG. 5 is an end view of the cooking tunnel of the conveyor oven of the present invention;

FIG. 6 schematically represents gas flow nodes for the conveyor oven of the present invention;

FIG. 7 is a front view of the ingress door microwave containment mechanism of the conveyor oven of the present invention;

FIG. 8 is a front view of the front side section illustrating a microwave slot antenna;

FIG. 9 is an exploded view of the microwave slot antenna of FIG. 8.

FIG. 10 is an end view of the front side of the conveyor oven illustrating gas flow deflecting means;

FIG. 11 is an end view of the back side of the conveyor oven illustrating gas flow deflecting means;

FIG. 12 illustrates the bleed gas flow of the conveyor oven of the present invention.

DESCRIPTION

The oven of the exemplary embodiment is shown as a three cook zone speed cooking commercial conveyor cooking appliance wherein each cook zone is shown to be manufactured in the same manner, although it is not necessary that each cook zone be the same and indeed in some instances it may be desirable that one or more cook zones be made differently. Our

conveyor oven may be built in other embodiments because it is scalable up or scalable down. The term "scalable" herein means that additional larger or smaller versions may be developed, and each embodiment or version may have different size characteristics and utilize different voltages of electricity; various forms of electric resistance heating means, or utilize other thermal sources such as natural gas, propane or other thermal means to heat the gas.

As used herein, the terms "magnetron", "magnetron tube" and "tube" have the same meaning; the terms "slot" "slots" and "antenna" have the same meaning; the term "commercial" includes, but is not limited to the commercial food service industry, restaurants, fast food establishments, speed service restaurants, convenience stores (to list a few) and other mass feeding establishments; the term "residential" refers, generally speaking, to residential applications (home use), although the term is not limited to residences only, but refers to non-commercial applications for the speed cooking oven and our speed cook conveyor oven is not limited to commercial uses only, and is equally applicable for vending, residential and other cooking uses; the terms "oven zone" and "oven cavity" have the same meaning and the term "gas" refers to any fluid mixture, including air, nitrogen and other mixtures that may be used for cooking and applicant intends to encompass within the language any gas or gas mixture existing or developed in the future that performs the same function. The term "cook zone" refers to a separate and discrete cooking area within the oven cooking tunnel and the term "cooking tunnel" refers to that area of the conveyor oven wherein cooking takes place. For example, in a one cook zone speed cooking conveyor oven, there will exist one cook zone and one cooking tunnel. In a two cook zone speed cooking conveyor oven there will exist two cook zones but only one cooking tunnel, and so on. The means for moving the food product through the speed cooking conveyor oven is referred to herein as the "conveyor transport means". The terms "dwell time"

and "cook time" have the same meaning. and the terms "conventional cooking" and "conventional means", have the same meaning and refer to cooking at the quality level and at the speed that is currently widely utilized. By way of example, the "conventional cooking time" for a fresh 10-12 inch pizza through a conventional oven is approximately 7 minutes (e.g. conventional cooking time). The term "cooking by-products" refers to smoke, grease, vapors, small aerodynamic grease particles, odors, and other products caused by the cooking process and the term "odor filter" does not refer exclusively to filtering of odors, but instead refers generally to filtering, reduction of, removal of or catalytic destruction of by-products of the cooking process.

As used herein, the term "rapid cooking" and "speed cooking" have the same meaning and refer to cooking at five to ten times faster, and in some instances more than 10 times faster than conventional cooking. The term "accelerated cooking" has the meaning of cooking at speeds faster than conventional cooking but not as fast as speed cooking.

The exemplary embodiment employs the use of an indexing conveyor transport means wherein the operating speed or feed rate is fixed, meaning that each cook zone holds food product for the same length of time. The dwell time may be varied or fixed, may be altered either manually or by controller 334 (see FIG. 3), and is not limited. The indexing motion of the conveyor transport means is a cycle consisting of a traverse to move food product to the next cook zone followed by a dwell or cooking period wherein the food product is stopped within a cook zone. This indexing motion insures that the energy delivered to the food product may be individualized for each food product. Control of the energy applied to the food product is important particularly in those instances wherein the conveyor oven is to cook a variety of food products successively and the cooking profile, or cook recipe must be adjusted as the different

food products enter the oven tunnel. The conveyor oven may operate as a conventional, accelerated or speed cooking conveyor oven.

Appliance 301 includes cook zones 380, 381 and 382 within cooking tunnel 394, FIG. 4. The cook zones may be spaced together or a distance apart, depending upon the particular conveyor oven that is desired. Each cook zone is generally defined by an oven cavity 302, FIG.5, a top wall 303, a bottom wall 304, a front side wall 305 and a back side wall 306. Front wall 305 is comprised of top gas discharge plate 323a, microwave launcher 320a (when microwaves are utilized) and lower gas discharge plate 327a. Back side wall 306 is comprised of top gas discharge plate 323b, microwave launcher 320b (when microwaves are used) and lower gas discharge plate 327b, FIG. 5. In those instances wherein microwave energy is not utilized in the conveyor oven, front and back side walls 305 and 306 may be comprised of a sheet of metal instead of front of waveguides 320a and 320b. Oven cooking tunnel 394 has associated therewith a movable ingress door 398 and a movable egress door 397, FIG.1. Food product 310, FIG. 4 is placed on conveyor transport means 399 for indexed transport through oven tunnel 394. As previously described, indexed motion is not required and a continuous transport means may be utilized in those instances wherein microwave energy is used and means other than ingress and egress doors are employed in order to contain the microwave energy within cooking tunnel 394. Although doors 397, 398 are shown as movable vertically relative to the conveyor transport means, other door opening and closing means may be employed; such as side-hinged doors, top hinged doors or doors utilizing other attachment means, and applicant does not intend to be limited but rather intends to encompass within the language any structure presently existing or developed in the future that performs the same function as doors 397, 398.

The conveyor oven is comprised of two independent gas transfer systems, described herein as a front gas transfer system and a back gas transfer system, wherein the front gas transfer system 393a delivers gas to and from the front side of cook zones 380, 381, 382, FIG. 3, and back gas transfer system 393b delivers gas to and from the back side of the cook zones 380, 381, 382. Cook zones 380, 381, 382 may also have associated therewith vent tube 371, FIG 5, which allows for the passage of vent gas from any one, or all, of cook zones 380, 381, 382 to atmosphere. Affixed within vent tube 371 may be vent odor filter 372, which provides for the removal of cooking by-products. Vent odor filter 372 may be made to be removable for cleaning or replacement and various materials, including catalytic materials, may be utilized to accomplish odor removal. In some instances, varying efficiencies of said materials may also be employed in order to allow various amounts of odors to escape the oven cavity.

Referring again to FIG. 3, gas is transferred to cook zones 380, 381, 382 via front gas transfer conduit 393a extending from gas flow means 316a to first cook zone 380, then continuing to second cook zone 381 and terminating with third cook zone 382, FIGS 1, 3. In fluid connection with front conduit means 393a are gas flow nodes 390a, 391a, 392, FIG. 6, which allow for the passage of gas from gas transfer conduit 393a to top gas transfer section 317a, FIG. 5, of each cook zone 380, 381 and 382. In fluid connection with top gas transfer section 317a is top gas egress opening 312, FIG.2, within each cook zone, which is open to, and in fluid connection with oven zone 302 through top wall 303. Top gas egress opening 312 is substantially rectangular, although other geometries may be employed, and is centrally located within each oven top wall 303 and provides for the passage of gas from oven zone 302 into return conduit means 389, FIG. 1 which returns gas from oven zone cook zones 380, 381, 382 to gas flow means 316a as gases are removed from oven zone 302 through top egress gas egress

opening 312. Located within each top gas egress opening 312 may be grease extractor 313, FIG. 2. As gas is drawn through top gas egress opening 312 of each oven zone, the gas passes across grease extractor 313, which removes the larger grease particles. By extracting the larger grease particles managing grease build-up in the down stream conduits and heater area is simplified. It may be desirable for each cook zone to utilize grease extractor 313, or alternatively no grease extractor, or still further additional grease extractors may be placed throughout the gas flow path.

During normal cooking it may be desirable for one food product to be cooked after another different type of food product with successive cycles continuing. For example a food product such as shrimp may be cooked first, followed by a baked product or pastry. Without appropriate filtration, the cooking by-products will contaminate the baked product, producing an undesirable taste and odor in the pastry. Although grease extractors 313 may be utilized, further gas filtration may be desirable and odor filters 343, FIG. 2 may be placed within any or all cook zones or within the oven tunnel and may be placed upstream of blowers 316a, 316b to be discussed further herein, and may be made of various materials including catalyst materials such as a corrugated foil coated with catalyst, or catalyst coated screens. The catalyst acts to combust (oxidize) the cooking by-products. Such catalyst materials may also include, but is not limited to: activated charcoal, zeolite or ultra violet wavelight light. It is beneficial that the odor filters be comprised of a material, or materials, that effectively scrubs, or cleans the gas flow with a minimal amount of interference with the gas flow velocities and it is beneficial that the odor filters be easily removed, easily cleaned and inexpensive for the operator to replace. The most efficient utilization of the spent hot gas from cook cavity 302 is by re-circulation of the gas through the oven tunnel many times during a cooking cycle. In some uses, it may be desirable to

utilize additional odor filters, which may be placed anywhere within the gas flow path. Depending upon the various levels of cooking by-product control that may be desired depending upon the food products to be cooked, the particular use of the oven, or the requirements of regulatory agencies, or other factors, in order to minimize cooking by-products within each oven zone, the oven tunnel or the gas flow supply and return conduits may therefore include one odor filter per appliance 301, "n" number of odor filters as determined by "n" cook zones, or more than "n" number of odor filters.

As used herein the term "upstream" refers to a location within the gas flow path that comes before gas flow means 316a and 316b. For example, gas that is supplied to gas flow means 316a, 316b is upstream of gas flow means 316a, 316b and gas that is discharged from gas flow means 316a, 316b is downstream of said gas flow means. The exemplary embodiment illustrates gas flow means as blower wheels 316a, 316b, although our invention may utilize a single gas flow device, such as a single blower wheel and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as 316a, 316b. Blower wheels 316a, 316b act much like centrifugal separators that will separate and coalesce the small grease particles in the blower scroll area and discharge larger particles into the supply area.

In an alternate embodiment, a portion of the gas flow leaving gas flow means 316a, 316b is diverted to the inlet side of gas bleed chamber 365a, 365b with odor filters 340 located within bleed chambers. The portion of gas flow diverted to said bleed chamber is referred to herein as the "bleed gas flow." The bleed gas flow passes through odor filter 340, FIG. 12 shown as a catalytic converter, where a portion of the cooking by-products is oxidized. Cleaner gas leaving odor filter 340 is either reintroduced into the gas flow stream or is vented to atmosphere via vent

tube 371. Odor filter 340 will remove the desired amount of grease during a single pass as the small bleed gas flow will continually remove grease generated during cooking. Indeed, in some embodiments it may be desirable for the odor filter to remove all, or as much cooking by-product as possible. Varying destruction efficiencies of odor filter 340 will produce varying results and in those instances wherein odor filter 340 is of the catalytic type, destruction efficiencies of greater than 50% have shown to produce acceptable results. The bleed gas flow is configured as an internal cleaning gas loop operating separate from the main gas flow to oven tunnel 394. In those instances wherein odor filter 340 is a high efficiency catalytic type filter for high cooking by-product destruction efficiencies, a large pressure drop may occur across odor filter 340. Space velocities for the catalytic converter range are typically in the range between approximately 60,000/hr to 120,000/hr depending on the catalyst material utilized, the amount of cooking by-product loading in the gas stream and odor filter 340 inlet ambient temperature. Unlike the placement of odor filter 343 in the main gas flow which results in a significant pressure drop on the entire re-circulating gas flow, the use of bleed gas catalytic type filters, or other odor filters, does not significantly reduce gas flow system pressure to oven tunnel 394. The small bleed gas flow utilizes nearly the entire pressure capability of the gas flow means through the gas bleed system, thereby permitting the use of catalytic materials required for a high destruction efficiency, based on one pass through odor filter 340. Additionally, the small bleed gas odor filters 340 are easily installed, can be placed in convenient locations and readily accessible. Bleed gas flows are a fraction of the main gas flow to the oven tunnel, therefore significant inlet gas temperature preheat may be achieved. Placing small gas pre-heaters 341a, 341b, FIG. 12 prior to odor filters 340 within the bleed gas flow system may additionally provide substantial improvement in the destruction efficiency of odor filter 340. Pre-heaters 341a, 341b

are capable of increasing the gas inlet temperature by greater than 100°F (37.78 °C)and this temperature increase in the bleed gas to odor filter 340 makes it possible to achieve the desired destruction efficiency with less catalyst material. In some instances a main gas flow odor and cooking by-product clean-up system may have difficulty cleaning the gas when oven set point is under approximately 425°F (218.3°C). Pre-heaters 341 are capable of producing cooking by-product control with oven tunnel temperatures below350°F (176.67°C). Additional appliance flexibility is achieved by simultaneously permitting lower oven cook temperature setting while providing grease control.

The bleed gas flow is approximately 10% of the total gas flow, blowers 316a, 316b, and pre-heaters 341a, 341b would each provide approximately 600 watts of heat for a 100°F (37.78°C) rise in gas inlet temperature. The combined 1200 watts of heating is less than one third of the total heat required for each oven zone of conveyor oven and is very close to the heat needed to satisfy standby losses of the oven (i.e., heat loss due to conduction, radiation, vent losses to ambient). As such, the pre-heaters can be the primary gas heaters with the larger (for this example 3000W) main gas heater used to satisfy cooking needs.

As previously described, in fluid connection with, and located within return conduit means 389 is a front gas flow means, illustrated as front blower wheel 316a, FIGS. 1,5. Our invention may utilize variable speed blower motors and variable speed blower motor controllers, but there is no requirement for their use and indeed the conveyor oven of the present invention may avoid the problems and complexity of variable speed blower motors by maintaining a constant gas flow, or alternatively, a substantially constant gas glow rate through the oven zones, oven tunnel and gas transfer and gas delivery systems. The gas flow may be very aggressive, or

less aggressive, depending upon the cooking requirements for each food product and one means to achieve gas flow modulation is by use of a gas pumping means such as a blower motor, blower wheel combination, utilizing a controller or a multi speed switch that allows for the switching of the blower motor speed in pre-determined fixed increments. Other gas flow means may be utilized to accelerate the gas flow, and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as 316a, 390a, 391a and 316b, 390b and 391b, to be discussed further herein. Connected to front blower wheel 316a is blower motor shaft 390a, which is direct drive with electric motor 391a, FIG. 5. Other means may be employed for coupling blower wheel 316a to electric motor 391a, such as belt drive and the drive means is not limited to direct drive and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function. Blower wheel 316a takes gas from return conduit means 389 and delivers the gas via conduit means 393a to node sections 390a, 391a, 392a, FIG. 6. Within node sections 390a, 391a, 392a are gas flow control means 388a, FIG. 1, which allow for the passage of gas from conduit means 393a to gas transfer section 317a of each oven zone. Gas flow control means 388a may allow for the passage of varying quantities of gas, or no gas, to transfer section 317a of each cook zone and are shown as valves 388a, although other means may be employed in order to allow, limit or restrict the gas flow to each oven zone 380, 381, 382 by nodes 392a, 391a, 390a and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as valves 388a.

Top front gas transfer section 317a, FIG 5, is in fluid connection with a lower front gas transfer section 318a via a front vertical gas transfer section 319a. Front vertical gas transfer section 319a is bounded by front side wall 366 and a front microwave waveguide section 320a,

when microwaves are used. When microwaves are not used, waveguide launcher 320a may be replaced by metal. As can be seen in FIG. 5, as gas is supplied into top front gas transfer section 317a, the gas is discharged through a top front gas discharge plate 323a into oven zone 302 via apertures 300a and onto the front top and front side portion of food product 310. Apertures 300a may be slotted, regularly formed or irregularly formed apertures and are illustrated herein as nozzles 300a and 300b, 329a, 329b, FIG. 5, and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as 300a, 329a and 300b and 329b, discussed further herein. Gas that has not been discharged through top front gas discharge plate 323a flows to lower front gas transfer section 318a via vertical transfer section 319a. Gas that is distributed to lower front gas transfer section 318a may be re-heated, if desired, by a lower front heating means 303a, FIG. 5, before said gas passes through slotted or perforated lower front gas discharge plate 327a via apertures 329a, for discharge onto the front bottom and front side portions of food product 310 in oven zone 302. Lower front heating means 303a may be present in some embodiments and not present in others depending upon the particular requirements for the speed cooking conveyor oven. Although lower front heating means 303a is shown as an electric open coil heater, other means to heat the gas may be utilized such as other types of electric heating means, electric resistance elements, natural gas, propane or other heating means and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as 303a and 303b to be discussed further herein. Apertures 300a and 329a are sized for a low pressure drop, while providing and maintaining sufficient gas velocities in the range of approximately 2000 ft/minute (609.6 meters/minute) to approximately 6000 ft/minute (1828.80 meters/minute) to properly cook the food product as described herein. In some instances,

velocities below 2000 ft/minute (609.6 meters/minute) or above 6000 ft/minute (1828.80 meters/minute) may also be utilized, depending upon the particular food product to be cooked, or a particular cooking recipe that the controller is executing, to be discussed further herein, and applicant does not intend to limit the invention to gas velocities within a particular range. Apertures 300a are sized such that the majority of the gas is supplied from top front gas discharge plate 323a. The resulting imbalance of gas flows between the top front gas discharge plate 323a and lower front gas discharge plate 327a is desirable because the top flows must aggressively remove moisture produced and escaping from the top and top side surfaces of the food product 310. The gas flow imbalance also serves to heat, brown and/or heat and brown the food product 310.

Referring again to FIG. 3, gas is transferred to the back of cook zones 380, 381, 382 via a back gas transfer conduit 393b, FIG. 3, extending from gas flow means 316b to first cook zone 380, then continuing to second cook zone 381 and terminating with third cook zone 382, FIGS 1,3, in the same manner as previously described for front gas transfer section 393a. In fluid connection with back conduit means 393b are gas flow nodes 390b, 391b, 392b, FIG. 6, which allow for the passage of gas from gas transfer conduit 393b to top gas transfer sections 317b, FIG. 4, of each cook zone 380, 381 and 382. In fluid connection with top gas transfer section 317b is the previously described top gas egress opening 312, which is in fluid connection with return conduit means 389b. Return conduit means 389b is in fluid connection with a back gas flow means, illustrated as back blower wheel 316b, FIG.3. As with blower wheel 316a, other devices may be utilized for gas flow means 316b to accelerate the gas flow, and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function. Connected to back blower wheel 316b is blower motor shaft 390b,

which is direct drive with electric motor 391b, and as with electric motor 391a other means may be employed for coupling blower wheel 316b to electric motor 391b. Blower wheel 316b takes gas from oven zone 302 via common return conduit means 389 and delivers the gas via conduit means 393b to node sections 390b, 391b, 392b, FIG. 6. Within node sections 390b, 391b, 392b are gas flow control means 388b, FIG. 5, which allow for the passage of gas from conduit means 393b to transfer section 317b of each oven zone. As with gas flow control means 388a, flow control means 388b, FIG. 5, may allow for the passage of no gas, or varying quantities of gas to transfer section 317b and are shown as valves 388b although other means may be employed in order to limit or restrict the gas flow to each oven zone 380, 381, 382 and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as valves 388b.

Top back gas transfer section 317b, FIG 5, is in fluid connection with a lower back gas transfer section 318b via a back vertical gas transfer section 319b. Back vertical gas transfer section 319b is bounded by back side wall 367 and back microwave waveguide section 320b. As can be seen in FIG. 5, as gas is supplied into top back gas transfer section 317b, the gas is discharged through a top back gas discharge plate 323b into oven zone 302 via apertures 300b and onto the back top and back side portion of food product 310. Apertures 300b may be slotted, regularly formed or irregularly formed apertures and are illustrated herein as nozzles 300b and 329b, FIG.5, and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as 300b and 329b. Gas that is distributed to lower back gas transfer section 318b may be re-heated, if desired, by a lower back gas heating means 303b, FIG. 5, before said gas passes through slotted or perforated lower back gas discharge plate 327b via apertures 329b, for discharge onto the back bottom and back side

portions of food product 310 in oven zone 302. Lower back gas heating means 303b may be present in some embodiments and not present in others depending upon the particular requirements for the speed cooking conveyor oven and as with gas heating means 303a, previously described, may be made of any material that accomplishes heating of the gas. Apertures 300b and 329b are sized for a low pressure drop, while providing and maintaining sufficient gas velocities in the range of approximately 2000 ft/minute (609.6 meters/minute) to approximately 6000 ft/minute (1828.8 meters/minute) to properly cook the food product as described herein. In some instances, velocities below 2000 ft/minute (609.6 meters/minute) and above 6000 ft/minute (1828.8 meters/minute) may also be utilized. Apertures 300b are sized such that the majority of the gas is supplied from the top back gas discharge plate 323b. As with the front gas system, the resulting imbalance of gas flows between the top back gas discharge plate 323b and lower back gas discharge plate 327b is desirable because the top flows must aggressively remove moisture produced and escaping from the top and top side surface of the food product 310. The imbalance also serves to heat, brown and/or heat and brown the food product 310.

The front and back gas supply systems, although independently described herein, are the same configuration and function to uniformly circulate hot gas flow across the top and top sides and bottom and bottom sides of the food product, and return the gas to the heating mechanism and gas flow means for re-delivery to the oven zones. Although the same configuration is shown in the exemplary embodiment no requirement exists for this symmetry and the front gas supply system may be configured differently than the back supply system, and the top gas supply systems configured differently from the bottom. Indeed, each cook zone may be configured differently than the other cook zones and many combinations of configurations may be desirable

for the particular conveyor oven. When a single cook zone conveyor oven is desired, various combinations, as previously described may also be utilized.

As previously described, gas flow is delivered via four gas transfer sections 317a, 317b, 318a, 318b which are located in the top and bottom corners of each oven cavity 302 as shown in FIG. 5. Gas flow transfer sections 317a, 317b; 318a and 318b extend the width of each oven zone 302, although it is not required that the gas flow transfer sections extend the entire length of the oven zone. Gas transfer section 317a is located in the top front corner of oven zone 302, FIG. 5, where top wall 303 intersects oven zone front side wall 366; gas transfer section 317b in the top back corner where top wall 303 intersects back side wall 367; gas transfer section 318a in the lower front corner of the oven zone 302 where bottom wall 304 intersects front side wall 366; and gas transfer section 318b in the lower back corner where bottom wall 304 intersects back side wall 367. Each gas transfer section is sized and configured to deliver the appropriate gas flow for the particular oven utilized. For example, in a smaller oven, the gas delivery sections, indeed the entire oven, may be sized smaller in proportion to the smaller footprint of the particular requirements, and a larger oven may have proportionally larger gas delivery sections.

As seen in FIG. 5, the front side and the back side gas flows converge on food product 310 creating an aggressive gas flow field on the food product surface that strips away the moisture boundary layer. This turbulently mixed gas flow directed at the food product can best be described as glancing, conflicting and colliding gas flow patterns that spatially average the gas flow over the surface area of the food product producing high heat transfer and moisture removal at the food product surface, thereby optimizing speed cooking. The gas flow is directed towards the top, the bottom and the sides of the food product from the front and back sides of the oven zone and the front and back side gas flows conflict, collide and glance off each other at the

food product surface before exiting the oven zone through top gas egress opening 312. As used herein the term "mixing" refers to the glancing, conflicting and colliding gas flow patterns that meet at and upon the top surface, the bottom surface and the front and back side surfaces of the food product and produce high heat transfer for both conventional and speed cooking of the food product due to spatial averaging of the gas flow heat transfer. The mixing gas flows patterns are created within the oven zone and, when appropriately directed and deflected, produce a high quality cooked food product that can also be cooked very quickly. Although speed cooking of high quality food product may be accomplished with this invention, conventional cooking may also be accomplished by adjusting the gas flow and microwave energy (in instances wherein microwave energy is utilized) to the food product; or by use of gas flow alone with no microwave energy. Enhancing the highly agitated, glancing, conflicting, and colliding gas flow is the general upward flow path the gas will follow, as shown in FIG. 5 through top gas egress opening 312, as the gas exits the top of oven zone 302. This upward gas flow draws also the gas from lower gas discharge sections 318a and 318b thereby scrubbing the bottom of the food product, pot, pan or other cooking vessel, by pulling gas flow around the sides of said vessel, further enhancing the heat transfer, as well as drawing the gas that scrubs the upper surface up towards the oven zone top wall.

Returning to FIG 5, top gas discharge plates 323a and 323b are positioned within oven zone 302 such that the gas flow from top gas transfer section 317a conflicts and collides with the gas flow from top gas transfer section 317b upon the food product surface and strikes the food product at an angle that is between zero degrees and 90 degrees as referenced from the horizontal top wall (where zero degrees is parallel to the horizontal top wall) and lower gas discharge plates 327a and 327b are positioned within oven zone 302 such that the gas flow from lower gas

transfer section 318a conflicts and collides with the gas flow from lower gas transfer section 318b upon the lower surface of the food product at an angle that is between zero degrees and ninety degrees as referenced from the horizontal bottom wall. Various cooking requirements may require that the angle of the gas discharge plates 323a, 323b, 327a and 327b be adjusted, either during manufacture, or adjustable within the oven after manufacture, in order for the chef or cook to change gas flow velocity angles (vectors) to effect different cooking profiles.

The number and placement of the apertures 300a, 300b, 329a and 329b will vary according to the particular oven that is desired. For example, a general purpose speed cooking conveyor oven may be scaled to a baking oven by changing the number of apertures, which may be fewer in number but be larger in size, thereby allowing for a more gentle gas flow across the food product, and producing proper delicate baking of the food product. If a browning oven were desired, the apertures may be more numerous and smaller in diameter. Additionally, the operator may desire more flexibility of cooking and in this circumstance gas discharge plates 323a, 323b, 327a and 327b may be fabricated in a manner that allows for quick change-out of the plates by the operator. As used herein the term "aperture" refers to irregular slots, irregular holes or irregular nozzles, regularly formed slots, regularly formed holes or regularly formed nozzles or a mixture of regularly formed and irregularly formed slots, holes or nozzles. FIG. 5 illustrates the use of three rows of apertures 300a and 300b on top gas delivery sections 317a and 317b, and two rows of apertures on the lower gas delivery systems 318a and 318b, although more or fewer rows and numbers of apertures may be utilized and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function. The gas delivery system as illustrated in FIG 5 produces aggressive glancing, conflicting and conflicting gas flow patterns 330a and 330b wherein an aggressive top glancing,

conflicting and colliding gas flow pattern 330a also interacts with the front top portion and front top side portion of food product 310 and a similar back top glancing, conflicting and colliding gas flow pattern 330b interacts with the back top portion and top back side portion of food product 310. Aggressive glancing, conflicting and colliding gas flow 331a interacts with the lower front and side portions of the food product and gas flow 331b interacts with the lower back and side portions of the food product. This cooking profile creates high heat transfer capability by using the surface of the food product, as well as the interference of flow fields to minimize boundary layer growth. After the aggressive glancing and conflicting gas flow patterns 330a and 330b contact or strike the food product they are exhausted through top egress section 312 and cycle back through the oven as described herein. The highly turbulent flow of the conflicting gas patters described herein has several benefits. First, the conflicting gas flow patterns create cook zone gas flow that is averaged spatially, or a flow condition that tends to average out the high and lows in flow variation for a given point in the cook cavity greatly reduces the design complexity needed to impose a uniform flow field over a cooking zone. In those instances where gas transfer sections 317a, 317b, 318a and 318b are in use, conflicting gas flows produce an “X” style gas flow wherein high heat transfer rates needed for speed cooking average the flow conditions over space and time, thereby producing uniform cooking and browning.

Another advantage of the upward return gas path is that a conveyor transport means may pass through the cook zones because the two ends of cook cavity 302 are now free of any gas flow means or microwave related subsystems (i.e., no blower return gas path or microwave feeds). Also, uniform side browning is effected because the bottom gas flow is drawn past the food product edges as the gas flows up to egress point 312 within roof 303. Third, grease loading in the return gas stream is reduced.

Gas flow control to the various zones is accomplished via simple gas flow dampers or valves, referred to as nodes 390a, 390b, 391a, 391b, 392a, 392b. This approach maintains a relatively constant flow through the oven thereby eliminating the need for varying the blower speed. The gas flow within the conveyor oven, as well as other functions of cooking appliance 301 are directed by controller 334, FIG. 3. Speed cooking of individual food products generally requires a separate cooking profile or recipe for that food product. The speed cooking conveyor oven of the exemplary embodiment is capable of cooking various food products at the same time, therefore the oven controls must track the food products as they move through the cook zones and adjust the gas flow energies, and microwave energies (when microwave energy is used) of each cook zone according to the cooking recipe that has been input by the operator or input by a scanning device, or other device for each food product. The cooking profile for a food product, referred to herein as the "cooking recipe" may be quite complex and time and labor expense associated with inputting cooking recipes may be minimized by use of controller 334 loaded with predetermined cooking recipes from a smart card, or loaded from an automated product identification device, or other scanning and reading devices may be utilized. Alternate embodiments will allow the operator to place the food product onto conveyor means 399 in loading zone 396, FIG. 4 and a unique product identification code could be used to transfer recipes to the oven controller, thereby eliminating manual cooking recipe inputs. Alternatively, manual single button entries, or multiple button entries may be made by the operator to input the cooking recipes and applicant does not intend limitations concerning the use of the control system for cooking recipes. Indeed optical scanners may be utilized at the ingress end of appliance 301. The exemplary embodiment describes a unique product identification code that is encoded with the correct cooking recipe settings for each food product and the transfer of

information is accomplished using an Radio Frequency Identification ("RFID") tag placed on the food or food packaging. The RFID tag may be programmed from the restaurant point of sale system and read by the oven controller by any means known such as cable linked one way communication, two way communication, wireless or other means and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the communication function. Reading of the RFID tag by controller 334 minimizes error associated with the operator imputing an incorrect oven cooking recipe and allows the restaurant to optimize customer service as the oven controller communicates with the point of sale system during the cooking cycle for each food product. Controller 334 determines, among other things, the velocity of gas flow, which may be constant or varied, or, may be constantly varied throughout the cooking cycle and whether or not gas is delivered through the previously described cooking nodes to cook zones 380, 381, 382. It may be desired to cook the food product on one velocity throughout the entire cooking cycle, or to vary the gas velocity depending upon conditions such as a pre-determined cooking recipes, or vary the gas velocity in response to various sensors that may be placed within the cooking zone, oven return gas paths or various other positions within the oven. The location and placement of said sensors will be determined by the particular application of the oven. Additionally, other means may be utilized wherein data is transmitted back to controller 334, and thereafter controller 334 adjusts the cooking recipe in an appropriate manner. For example sensors (temperature, humidity, velocity, vision and gas borne chemical mixture level sensors) may be utilized to constantly monitor the cooking conditions and adjust the gas flow, and microwave energy, when used, accordingly within a cooking cycle, and other sensors not described herein may also be utilized and the speed cooking conveyor oven may utilize sensors that are not currently commercially practical due to

cost or other limitations (such as laser, non-invasive temperature sensors and other sensors that are currently too expensive to be commercially feasible), and the speed cooking oven is not limited to those discussed herein, as many sensing devices are known and utilized in and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function. Additionally, controller 334 may control the amount of bleed gas flow through each odor filter 340, as previously described. For example, oven zone 380 may contain a food product that, upon conventional cooking, or speed cooking, will produce larger amounts of airborne grease, smoke and odor than the food products in the other cooking zones. In such an instance, controller 334 may allow for more gas flow to pass through odor filter 340 of oven zone 380 and either allow more or less gas flow to odor filters that may be utilized for oven zones 381, 382 and to adjust pre-heaters 341a, 341b of oven zone 380.

Gas flow may also be adjusted as a function of available power. In the event, for example, the heating means of an all electric speed cooking conveyor oven is requiring or utilizing a large amount of power (larger than available power levels which may vary according to location and local code and ordinance) it may be desirable for controller 334 to reduce electrical power to the heating means or other electrical components in order to conserve available power. In a speed cooking conveyor oven, some systems may be powered by electric current, but the electric power requirements will not be as high as required for an all electric oven because the energy required for gas heating and cooking will be provided by the combustion of a hydrocarbon based fuel. In this event a controller may not be required, indeed knobs or dials may be utilized.

In an alternate embodiment, gas flow control may be accomplished by gas flow control means, FIGS. 10, 11. As gas is discharged into top front gas transfer section 317a, a selected portion of said gas may be directed through apertures 300a within gas discharge plate 323a by gas deflecting means 324a, shown in the open position, Fig. 10. Gas deflecting means 324a is shown as pivotally attached to gas discharge plate 323a, although, other means for accomplishing said gas deflection may be utilized. For example means such as normally open, normally closed, or normally partially open and normally partially closed switched plates may be used (wherein said plates slide along the inside of perforated plate 323a to limit the aperture openings 300a of discharge plate 323a), and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as gas deflecting means 324a. Gas that has not been discharged or deflected through apertures 300a flows to lower front gas transfer section 318a via vertical transfer section 319a. Pivotally attached to waveguide section 320a (when waveguides are used and to sheet metal when not used) is a lower gas transfer deflection mechanism 352a, FIG. 10 that operates to limit the amount of gas that is transferred to lower gas transfer section 318a. As used herein, the terms "flow control means" "gas deflecting means" "transfer deflection mechanism" and "flow control means" all have the same meaning and refer to means to control gas flow within and to various parts of the conveyor oven. Indeed, certain cooking operations may call for more gas flow to the lower part of the conveyor oven, while other operations will call for little or no gas flow to the bottom side of the oven for delivery to the bottom of the food product. In those instances where little or no gas flow is desired upon the bottom surface of the food product, gas transfer deflection mechanism 352a may be closed in order to allow all, or substantially all, of the gas flow into top front gas delivery section 317a.

Gas that flows to lower front gas delivery section 118a may be re-heated, if desired, by lower front heating means 303a, FIG. 10. After passing over heating elements 303a, the gas may be further deflected by deflecting means 328a, FIG. 10, shown in the open position. As gas deflecting means 328a is rotated, directional control of the gas flow may be further refined, allowing for gas flow to pass through the upper or lower rows of apertures of lower gas plate 327a at various positions along food product 310 bottom surface, FIG. 10. Although gas deflecting means 328a is shown as pivotally attached to front slotted or perforated gas discharge plate 327a, gas deflecting means 328a is not limited to the pivotally attached means illustrated herein, and as described elsewhere herein, applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as gas deflecting means 324a, 352a, 328a, 324b, 352b and 328b to be discussed further herein.

As gas is discharged into top back gas transfer section 317b, a selected portion of said gas may be directed through apertures 300b within gas discharge plate 323b by gas deflecting means 324b, shown in the open position, Fig. 11. Gas deflecting means 324b is pivotally attached to gas discharge plate 323b, although as with 323a, other means for accomplishing said gas deflection may be utilized. For example means such as normally open, normally closed, or normally partially open and normally partially closed switched plates may be used (wherein said plates slide along the inside of perforated plate 323b to limit the aperture openings 300b of discharge plate 323b), and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as gas deflecting means 324b. Gas that has not been discharged or deflected through apertures 300b flows to lower front gas transfer section 318b via vertical transfer section 319b. Shown as pivotally attached to waveguide section 320b (when waveguides are used and to sheet metal when not

used) is a lower gas transfer deflection mechanism 352b, FIG. 11 that operates to limit the amount of gas that is transferred to lower gas transfer section 318b. As with the front gas transfer system, certain cooking operations may call for more gas flow to the lower part of the conveyor oven, while other operations will call for little or no gas flow to the bottom side of the oven for delivery to the bottom of the food product. In those instances where little or no gas flow is desired upon the bottom surface of the food product, gas transfer deflection mechanism 352b may be closed in order to allow all, or substantially all, of the gas flow into top front gas delivery section 317b.

Gas that flows to lower back gas delivery section 118b may be re-heated, if desired, by lower front heating means 303b, FIG. 11. After passing over heating elements 303b, the gas may be further deflected by deflecting means 328b, FIG. 11, shown in the open position. As gas deflecting means 328b is rotated, directional control of the gas flow may be further refined, allowing for gas flow to pass through the upper or lower rows of apertures of lower gas plate 327b at various positions along food product 310 bottom surface, FIG. 11. Although gas deflecting means 328b is shown as pivotally attached to front slotted or perforated gas discharge plate 327b, gas deflecting means 328b is not limited to the pivotally attached means illustrated herein, and as described elsewhere herein, applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function as gas deflecting means 324a, 352a, 328a, 324b, 352b and 328b.

In those instances wherein directional control of the gas flow is desired, gas deflecting means 324a, 324b, 328a, 328b and 352a and 352b, FIGS. 9, 10 may be rotated such that gas flow is diverted to selected apertures, thereby effecting a different gas flow pattern and gas mixing upon and above the food product surface. Additionally, in those instances wherein no bottom

side gas flow is desired, gas deflecting means 352a, 352b may be closed, thereby allowing for little or no passage of gas flow to the lower portion of the oven cavity. Various other adjustments of gas deflecting means are possible and applicant intends to encompass within the language any structure presently existing or developed in the future that allows for combinations of open and closed positions of apertures 300a, 300b, 329a and 329b by the various gas flow control means described herein. Gas deflecting means 324a, 324b, 328a, 328b and 352a and 352b may be manually controlled, automatically controlled via controller 334, controlled by other mechanical or electrical means, or controlled via combination of automatic and manual control and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the function described herein concerning adjustment of the gas deflecting means. In those instances wherein gas deflecting means 324a or 324b allow little or no gas through gas discharge plates 323a, 323b, and further wherein little gas flow is desired through lower gas discharge plates 327a, 327b, a by-pass return gas flow conduit may be provided in order to return gas flow to gas return conduit means 389. Additionally, in those instances wherein gas directing means 328a, 328b allow little or no gas through gas discharge plates 327a, 327b and less gas flow is desired through gas discharge plates 323a, 323b, a conduit means may be provided to return gas flow to return conduit means 389, or alternatively to atmosphere or to gas bleed system previously described for further odor and grease clean-up. Indeed, various and multiple combinations of gas flow control exist, depending upon the particular oven that is desired and gas flow may be directed to many and various apertures throughout the conveyor oven in order to accomplish the desired finished cooked product 310.

The oven of the present invention may also utilize microwave energy to at least partially cook the food product. As seen in FIG. 5, front side microwave launching waveguide 320a is

attached within oven zone 302 to front side wall 305 between top front gas discharge plate 323a and lower front gas discharge plate 327a. Back side microwave launching waveguide 320b is attached within oven zone 302 to back side wall 306 between top back gas discharge plate 323b and lower back gas discharge plate 327b. The microwave waveguides are designed to distribute microwave power from magnetrons 100, FIG. 8, uniformly from the back to the front of oven cook cavity 302. The vertical distance above cavity bottom wall 304 of waveguides 320a and 320b is such that, under normal cooking conditions, approximately more than one third of the microwave energy is available below food product 310, with the balance of microwave energy available above food product 310.

As shown in FIG. 5, microwave energy 351a, 351b, FIG. 5, is broadcast from waveguides 320a, 320b into oven zone 302 via a slotted antenna 370, FIG. 8, wherein three or four narrow apertures (slots) 370 are spaced along the waveguide. Various configurations for microwave distribution have been utilized with varying results and less than three slots may be utilized or more than three slots may be used, and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function. Important to an efficient and inexpensive slotted microwave system, FIG. 9 is the slot length 382, slot width, 383, the spacing between the slots, slot end spacing, angle of the slot relative to the long axis of the waveguide, the number of slots per waveguide and the slot orientation.

Slots 370 in waveguides 320a, 320b, are open to the cooking cavity and must be covered or protected so that grease and other contaminants cannot enter the waveguide and a durable and inexpensive slot antenna cover may be utilized to protect such slots 370. Slot antenna covers 106 FIG. 8, are configured to cover slots 370 in waveguides 320a, 320b. Slot antenna covers 106 are adhered to the surrounding stainless steel of waveguides 320a, 320b using high temperature

silicone rubber Room Temperature Vulcanizing ("RTV") sealant. This sealing approach creates high temperature watertight seal between the cover and the surrounding metal. Although an RTV sealant has been described in the exemplary embodiment, other sealant means may be utilized to adhere antenna covers 106 to waveguide 320a, 320b. The cover material must be compatible with high temperature operation, must be of low loss characteristics relative to microwave transmission, easily cleaned, durable, and inexpensive. For good microwave compatibility, materials with a dielectric constant less than 6 and a loss tangent less that 0.2 have been found to provide such characteristics. Such materials must be thin, generally less than 0.015 inches thick, and be suitable for gluing using (RTV). A Teflon(PolyTetraFluoroEthylene ("PTFE"))/fiberglass fabric produced by Saint Gobain (ChemFab Product Number 10 BT) which has one side treated to accepted silicone rubber and is 0.01 inches thick is described in the exemplary embodiment and has shown to have little impact on the microwave characteristics of the magnetron and microwave waveguide system Results of Smith chart testing and water rise experiments of the impedance of the waveguide and waveguide antenna for slot angles greater than 17 degrees(as measured from a horizontal centerline, 379, FIG.9) and without antenna cover 106 are approximately the same.

Although two microwave waveguides, 320a, 320b and two magnetrons, 100, are described per cooking zone, in other embodiments the waveguides may be supplied by one larger magnetron, or alternatively various numbers of magnetrons may be utilized and the invention is not limited to two magnetrons per cooking zone and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function.

For optimum cooking, food product 310 is placed within oven zone 302 upon conveyor transport means 399 a distance of at least 2.4 inches (for optimal cooking uniformity) from front side wall 305 and back side wall 306. The 2.45 inch measurement corresponds to one half a microwave wavelength or 2.4 inches (for optimal cooking uniformity) (E field null) for a 2.45 GHz microwave tube (microwave) frequency. This spacing permits the E-field to expand and become more uniform prior to coupling with the food product. Other side spacing placement may be utilized with other types of magnetrons systems.

The back side microwave waveguide is identical to the front side system and microwave energy is broadcast from back waveguide 320b to oven zone 302 via slotted antenna 370 as previously described for the front side. Although waveguides 320a and 320b are configured in the same manner, infinite combinations of slot designs, slot configurations, slot widths, slot lengths, numbers of slots per waveguides and slot orientations are possible per waveguide depending upon the type of oven desired. The microwave energy field therefore propagates through the oven zone in an evenly distributed pattern, coupling with the food product from all directions, and providing an even electromagnetic energy distribution throughout the oven zone without the need for a mechanical stirrer to propagate the electromagnetic field. Waveguides 320a and 320b are located on the front and back side walls of the oven, and therefore do not interfere with oven zone spent gas exhaust. Because microwave waveguides are located on the side walls of the oven zone, they are not affected by food spills, grease contamination, cleaning fluid contamination or other contamination that normally affect a bottom launch microwave system. The microwave system of the present invention will therefore be less likely to be penetrated by grease, spills, cleaning materials and other contaminants because the systems are not located directly under the food product where hot contaminants will drip. It is not required

that side launch microwave waveguide be employed and indeed microwave launching may be accomplished from any oven cavity surface, with varying degrees of efficiencies.

Microwave waveguides 320a, 320b, FIG. 5 with slotted antenna 370 are positioned along the front and back cavity walls such that cooking rack 308 is slightly below slots 370. In this manner, microwave energy is directed towards the top and bottom of the food product. For safety, microwave energy must be contained within cooking tunnel 394 and historically conveyor ovens incorporated long entrance and exit tunnels to attenuate the microwave leakage escaping from the open oven tunnel ends. These long tunnels not only require much additional floor space, but they result in oven cavity heights of only a few inches thereby greatly limiting the food products that can pass through such a conveyor oven. Our invention eliminates the need for long entrance and exit tunnels and short cooking cavity height by employing the indexing conveyor approach coupled with tunnel doors, 397, 398 FIG. 1, as discussed herein.

Exemplary food product flow is illustrated in FIG. 4. In order to reduce controller 334 complexity, the conveyor transport speed may be operated at a fixed rate. This approach establishes dwell times wherein food product 310 remains in a given cook zone for a fixed period of time. In addition to simplifying food recipe development and cooking recipe algorithms, a fixed dwell time also reduces complexities associated with conveyor drive mechanisms; resulting in a less expensive and more reliable conveyor transport means.

Food product 310 is placed upon conveyor transport means 399 and cook settings for product 310 may be inputted automatically or manually, as previously described, into controller 334. Conveyor indexing motion begins with the opening of ingress tunnel door 398, FIG. 1 and egress tunnel door 397. After doors 397, 398 open, conveyor transport means 399 moves in a direction toward the cooking zones, (or zone) a distance such that food product 310 indexes, or

moves forward to the first cook zone 380, FIG. 4 within oven tunnel 394. Once conveyor transport means 399 stops, doors 398 and 397 close around conveyor belt 399 as shown in FIG. 7, and initiation of the cooking cycle may begin. After conveyor means 399 comes to its initial stop, a second food product may be placed on conveyor transport means 399 at loading position 396, FIG.4. In those instances wherein microwave energy is used, a microwave seal must be achieved between conveyor belt 399 and doors 397, 398. Interface wall 387, FIG. 7 is attached to belt 399 and doors 397, 398 close around interface wall 387. The wall spacing on conveyor belt 399 corresponds to the pitch length (oven zone centerline to oven zone centerline). The space between the partitions or walls also defines the landing zone for product loading area 396, FIG.4. In addition to obtaining a seal for containment of microwave energy, closed doors 397, 398 reduce heat losses associated with open cooking tunnel ends where hot gas leaves the open tunnel ends with cool ambient gas rushing in to replace the lost hot gas.

The door and wall microwave interface configuration between movable doors 397, 398 and short wall 387, FIG. 7, on conveyor belt 399 is such that neither precise belt motion control (stopping at an exact location) or metal to metal contact between door edge 399 and the wall 387 is required. The wall and belt design is axially compliant. A one quarter wavelength choke 386, FIG. 7, is integrated into the bottom edge of doors 397, 398. Allowing for small displacement of the wall when the door closes is accomplished by the combination of the inverted “V” shape which guides door 398,397 together with short wall 387 by a compliant (not rigid) connection of wall 398 to belt 399. The inverted “V” shape has sufficient length to support a one quarter wavelength choke (approximately 1.2 inches). The indexing motion of speed cooking conveyor appliance 301 results in microwave containment within the cooking tunnel because the conveyor is stationary during the cooking process.

With product 310 now in cook zone 380, controller 334 begins the cooking recipe for food product 310. Cooking of food product 310 may be completed within cook zone 380 or may be cooked in zones 381 and 382, FIG. 3, and it is not required that food product 310 utilize all three cook zones for completed cooking. Indeed, some cook zones may be used to defrost frozen food product prior to cooking, or partial defrost followed by cooking. Dwell, or cooking time within each zone as previously described may be altered. The exemplary embodiment utilizes a 50 second conveyor dwell setting per cooking zone. Food product 310 entering cook zone 380 may therefore have a cooking recipe of 50 seconds comprised of 25 seconds wherein 100% microwave energy and 100% gas flow is applied; followed by 25 seconds in which 50% microwave energy and 100% gas flow is applied.

At the completion of the first 50 second dwell period, controller 334 begins the next indexing motion by opening tunnel doors 398, 397, FIG. 1 and conveyor transport means 399 moves, or indexes one pitch length forward, moving product 310 from first cook zone 380 to second cook zone 381, FIG. 4. In the event a second food product has been placed upon conveyor transport means 399 at loading position 396, FIG. 4, the second food product will move, or index into cook zone 380. The second food product's cooking setting may now be entered into controller 334 in the event the operator had not previously entered the cooking program, or the program had not been automatically loaded as previously described. Once conveyor transport means 399 stops, tunnel doors 398, 397 again close and controller 334 executes the cooking settings for the first food product in cook zone 381 and for the second food product in cook zone 380. Each food product is then cooked with its own cooking recipe. For example, the first food product in cooking zone 381 may require 100% gas flow and no microwave energy for the 50 second dwell period, while the second food product in cooking

zone 380 may have 3 events programmed for the 50 second dwell (e.g., 15 seconds of 100% gas flow with no microwave followed by 20 seconds of 100% microwave energy and no gas flow, followed by a final 15 seconds of 50% microwave and 50% gas flow). The number of events per cooking zone may be programmed in infinite combinations and applicant does not limit the endless possible combinations of cooking recipes by the exemplary embodiment.

At the completion of the second 50 second dwell period doors 398, 397 again open and the next conveyor transport means indexing motion is initiated. Assuming a third food product has been placed upon conveyor transport means 399 in holding area 396, third food product 310 will index forward to cooking zone 380, while the second food product will index forward to cooking zone 381 and the first food product will index forward to cooking zone 382. With the third food product now in cooking 380, each food product can now be cooked with its own cooking recipe setting in the manner as previously described. With the completion of the third dwell period, doors 397, 398 again open and conveyor transport means 399 indexes forward one dwell length and first food product 310 is now outside oven tunnel chamber 394 and resting upon transport means 399, ready for unloading by the operator.

As previously described, speed cooking conveyor 301 consists of one or more discrete cooking zones. The simplest one zone design will process only one product at a time. A multi-zone design of 'n' zones would have up to 'n' products in conveyor oven tunnel at a given time. The total capacity or speed cooking conveyor throughput (products per hour) is a function of the number of cooking zones and the total cook time for a product. For example, a one zone speed cooking conveyor with a 150 second dwell time will process approximately 24 products per hour. A three zone oven with 50 second dwell time zones and a total cook time of two and one half minutes (3 X 50 seconds) will process approximately 72 products per hour. A six zone

speed cooking conveyor with 25 second dwell times will process approximately 144 products per hour.

Because the food product is stationary in each cooking zone, the energy flows imparted to each food product may be controlled. Control of energy to the food product in a cooking zone includes the means to modulate both the microwaves, when used, and gas flow energies that may be introduced into the food product. A stationary food product during cooking also permits the uniform application of the cooking energies (microwave, convective and optional radiant). Each cooking zone 380, 381, 382 has open ends with a conveyor belt placed above and parallel to cook zone floor 304. The cook zones are placed end to end with the conveyor transport means passing through each cook zone and the zones are separate by a distance in order to minimize the influence of gas flows or microwave energies coupling between cook zones. The distances between cook zones will be determined by the particular conveyor oven that is desired, and the amount of interference between cook zones that may be considered acceptable.

Although the exemplary embodiment illustrates the use of a two blower design with one blower providing the gas flow to the front of each cook zone and a second blower for gas flow to the back of each cook zone, only one flow means, such as a blower may be utilized, or more than two gas flow means may be utilized and applicant intends to encompass within the language any structure presently existing or developed in the future that performs the same function.

Equipment bays for housing microwave circuit components, magnetrons, cooling fans, electronics, line filters, and other electrical components may be located on the front side of appliance 301.

For a three cooking zone speed cooking conveyor oven, approximately 300 cubic feet/minute (“cfm”) is utilized per cooking zone, although more than 300 cfm and less than 300

cfm of gas per cooking zone may be utilized. This produces a hot gas flow supply loop, FIG. 5, wherein the cook zones are supplied with hot gas flow once cooking zone valves 388a, 388b are opened. Actuation of the valves may be accomplished using solenoids or stepper motors 310a, 310b, FIG. 5, or any other means known to accomplish the function of opening and closing of valves 388a, 388b. This method permits the blowers to operate at fixed speeds, and guarantees that sufficient flow is always present for safe reliable operation of the gas heating source and grease clean-up system.

As previously described, a single energy source, heating means 314, with a single heat source controller, is used to supply heat to the gas returning to the blower 316a, 316b. This approach greatly simplifies the heating system as compared to distributing heat sources among the various cooking zones. High power electrical wiring or natural gas line connections may also be centralized. For a gas fueled heating means, only a single burner and ignition module are needed. The centralized approach results in both oven construction simplification and reduced maintenance.

Gas heating power requirements per cook zone of the exemplary embodiment are between approximately 5 and 7 kW for an electric appliance and 24 to 34 kBtu/h for a direct fired natural gas powered heater. An electric heater for the exemplary embodiment is sized between approximately 15 and 21 kW, while the gas fired gas heater would have a 72 to 102 kBtu/h need. For either power source, a standard temperature controller could be employed (i.e., maintaining the blower discharge temperature). For either a gas fueled or electric fueled appliance, as previously described, appliance 301 may be scaled to permit use of available power supplies. Additionally, a common gas heating means is ideal for ease of installation, service, and the ability to incinerate grease particles that come in contact with the very hot products of

combustion. Of course, the hot products of cooking by-product combustion are mixed with the gas returning to the blowers, resulting in a modest gas temperature increase of between 20°F(-6.67°F) to 60°F (15.56°C) and a number of combustor types are suitable for this application including a surface type burner.

Although the present invention has been described in considerable detail with reference to certain preferred versions thereof, other versions are possible. For example, various sizes of conveyor ovens, both conventional and speed cooking may be made. In these cases larger or smaller component parts may be utilized, and fewer or more components may be employed. In the case where it is desirable to make a smaller conveyor oven, one gas flow acceleration means may be utilized instead of two; one microwave system utilized instead of two; smaller or fewer thermal devices, whether electric resistance or gas fired may be used. In cases wherein it is desirable for a larger speed cooking oven, larger gas flow systems and microwave systems may be added to accomplish a larger speed cooking conveyor oven.

To summarize, the present invention provides for conventional and speed cooking conveyor ovens utilizing hot gas flow, and hot gas flow coupled with microwave energy in order to achieve conventional and speed cooking of food products. Conventional or speed cooking of food products five to ten times faster than conventional cooking with food quality, taste and appearance levels equal to and higher than that attained by conventional cooking. The speed cooking conveyor oven is operable on various power supplies and is simple and economical to manufacture, use and maintain, and is directly scalable to larger or smaller embodiments. The conveyor oven may operate as a gas fired, electric resistance fired oven, a microwave oven or a combination gas and microwave oven. Additionally, the invention may be practiced wherein no gas deflection means are utilized, such as in the exemplary embodiment, gas deflection means

are utilized as in alternate embodiments described herein. In cases wherein it is desirable for a larger production conveyor oven, multiple conveyors may be used with additional gas flow system and microwave systems

Other modifications and improvements thereon will become readily apparent. Accordingly, the spirit and scope of the present invention is to be considered broadly and limited only by the appended claims, and not by the foregoing specification. Any element in a claim that does not explicitly state "means for" performing a specific function, or "step for" performing a specific function, is not to be interpreted as a "means" or "step" clause as specified in 35 U.S.C. §112, ¶6. In particular, the use of "step of" in the claims herein is not intended to invoke the provisions of 35 U.S.C. § 112.